BELLCOMM, INC.

SUBJECT: APP-A Integration with AAP 1969 Missions - Case 600-1

DATE: March 29, 1967

FROM: P. L. Havenstein

ABSTRACT

The Apollo Applications Program is making preliminary plans to fly a package of 14 earth oriented experiments (APP-A) in a high inclination orbit in the latter part of 1969. In the same period the program plans to extend the duration of manned space flight by resupplying a high-altitude, low-inclination orbital workshop with repeated launching of CSMs. The compatibility of these two objectives is examined and the results suggest that the APP-A package should be flown separately because of the demanding payload requirements imposed on the CSMs by resupply consumables and high altitude. High inclination further compounds the payload problem.

(NASA-CR-89949) APP-A INTEGRATION WITH AAP 1969 MISSIONS (Bellcomm, Inc.) 13 p

N79-71556

Unclas
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FF No. 602(A

(PAGES) (CODE)

CR-89949
(NASA CR OR TMX OR AD NUMBER) (CATEGORY)

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MEMORANDUM FOR FILE

Introduction

The purpose of this memorandum is to discuss several possible methods of integrating the Applications-A (APP-A) earth resources experiment package with the AAP 1969 long-duration mission objectives. APP-A is a collection of 14 earth-oriented experiments which weigh about 2500 lbs. When integrated into a flight package, the weight will be a minimum of 3500 lbs. if integrated into an existing module or as much as 7500 lbs. if an independent carrier is required for structure, thermal control and power. The APP-A experimenters are strong in their desire to fly at an inclination no less than 50° in order to observe the United States. It is estimated that this experiment package would be available for flight in mid-1969.

The current plans of the AAP Program are to conduct in 1969 essentially continuous flight utilizing an orbital workshop and several resupply missions. The workshop may be already in orbit from the 1968 missions or a new one may be provided at an inclination yet to be established. There are, therefore, three possibilities for the flight of APP-A -- with the '68 workshop, with the '69 workshop or alone. For the first two of these possibilities, there is the question of whether the orbit inclination can be 50° instead of the planned 29°.

1968 Workshop at 50° Inclination

The establishment of the 1968 workshop configuration involves four launches: AAP-1 with a CSM and LMSS; AAP-2 with an airlock, a workshop and a docking adapter; AAP-3 with a CSM and resupply provisions; and AAP-4 with a LM/ATM. The assembled configuration is to be flown at an initial altitude of 260 nm in order that the assembly may be available for reuse in 1969.

If the inclination were to be changed from 29° to 50°, the payload would have to be reduced about 2000 lbs. for each of the launches. At the present time, the margin for each of the missions is near zero. For AAP-1 a combination of leaving the LMSS at low altitude and using a later launch vehicle than

SA-207 would be barely sufficient to provide for the payload loss. The LMSS, however, would have to be constrained to its current design weight without the augmentation which is the subject of current studies. For AAP-2 a redesign of the airlock, workshop, docking adapter and SLA would be required to keep the integrated configuration within a total payload weight of about 25,000 lbs. For AAP-3 the resupply provisions would have to be integrated into the CSM and would provide less than 56 days duration. For AAP-4 the LM/ATM would have to be constrained to a total weight of about 22,000 lbs.

While all of the above changes to permit flying the 1968 mission at 50° inclination are feasible, they would require that the missions be replanned, the systems redesigned and the first flight delayed. Before accepting such changes, it is necessary to evaluate the capability of the 1969 CSM to rendezvous the APP-A experiment package with the assembled configuration.

Payload Capability of 1969 CSM

Figure 1 shows the experiment payload capabilities during the 1969-70 resupply missions. The estimated altitude of the 1968 configuration is 240 nm. The orbital capability for 29° and 50° inclination is shown by the dotted lines. This capability is based on an insertion by the launch vehicle into a 81 x 120 nm orbit followed by an orbital transfer and rendezvous conducted by the CSM. The CSM assumed in this figure is "semi-quiescent" and weighs 26,200 lbs. including 2200 lbs. of SPS retro-propellants. For the purposes of parametric analysis of the flight duration requirements, this weight does not include the time-dependent oxygen, nitrogen, water, food or RCS propellants, nor the hardware associated with their storage. It does include a battery-only power system, an earth aligning G&N system, a "limited recycle" 2-gas environmental control system, an active RCS, a reliable SPS deorbit system, ECS cryogenic gas volume in SM Sectors III, IV and VI, and room for experiment mounting in Sectors I.

Parametrically, the expendables are estimated at 90 lbs. per day broken down as follows: leakage (O_2 and N_2)-35 lbs. per day; RCS propellant-10 lbs. per day; metabolic oxygen-8 lbs. per day; food-7 lbs. per day; water-15 lbs. per day, 5 lbs. per day for experiment data systems and 10 lbs. per day for SPS propellants associated with the rendezvous and deorbit of these expendables. All of the above figures (except propellants) include the associated storage or tankage weight in order to make them usable parametrically.

Figure 1 shows that a 90-day CSM mission uses the entire payload capability at an inclination of 29°. At an inclination of 50° the maximum flight duration would be about 67 days. The effect of the higher inclination can be best summarized by noting that five rather than four flights are required to give almost a year in orbit. There is at the same time no allowance for experiment payload (such as APP-A) and, therefore, no reason for the higher inclination.

If the minimum APP-A package of 3500 lbs. were incorporated, for instance, into Sector I and the consumables (but not their tankage) off-loaded, the flight duration for this one mission would be limited to about 45 days at 29° or 20 days at 50° inclination. An additional flight would be required to achieve AAP's one year objective, bringing the total resupply missions to five at 29° or six at 50°.

These conclusions are obviously quite sensitive to both the assumed weight of the various CSM modifications and the assumed rate of usage of expendables. The system is particularly sensitive to the atmospheric leakage of the assembled vehicle. At this stage in the design of the cluster, however, there are many configuration possibilities still being considered; and a more accurate appraisal will have to await the final selection of configuration and design characteristics.

New Cluster in 1969

If a new workshop and LM/ATM were to be launched in 1969, the data in Figure 1 still applies but with some modification. A follow-on configuration will probably have to take into account, for purposes of economy in non-recurring cost, the constraints of the high-altitude mission as well. Previous performance estimates have shown that for a 29° inclination synchronous mission a maximum of about 32,000 lbs. can be allocated to the airlock and expendables and that this will be reduced to about 26,000 lbs. if a higher altitude is sought to avoid the trapped radiation environment. This implies a light weight airlock without multiple docking provisions and weighing no more than 18,000 lbs., and reduced rate of expendable consumption (principally reduced leakage) approaching 50 lbs./day (without high altitude retro-propellants).

If the 1969 airlock is designed with the high altitude constraints in mind, there is a margin for experiments when launched unmanned on a Saturn IB to a 260 mile circular altitude. This margin is about 8000 lbs. at 29° inclination and 6000 lbs.

at 50° inclination which should be adequate for an APP-A integration and operation for extended periods of time. APP-A at the present time is conceptually a comparative evaluation of earth sensors and does not require extended operation to meet its objectives. If flown as an integrated part of the workshop, the design concepts would have to be reviewed and revised to be compatible with longer duration operations.

If the 50 lbs. per day expendable rate can be achieved, then Figure 1 shows that 160 days are possible at 29° and 110 days at 50°. A little more conservatively, but still a difficult goal, this represents three manned launches at 29° and four at 50° in order to achieve a year's flight.

Conclusions

1. A 90-day "semi-quiescent" CSM seems feasible when flown as a resupply vehicle in connection with a 1968 orbital assembly at 240 nm and 29° inclination.

2. There is no payload margin for experiments when this CSM is flown at maximum duration, and the off-loading of expendables to provide even the minimum APP-A package will require an additional flight to complete an AAP one-year objective.

3. If a new integrated workshop is planned for development in 1969 to either high earth orbit or low earth orbit, it could provide additional experiment capability within itself and the possibility of an extended duration version of APP-A.

4. The effect of increasing the inclination to 50° in either 1968 or 1969 is to shorten each of the resupply mission durations and to increase by at least one the number of flights per year of continuous operations.

5. Even at an APP-A minimum integrated weight of 3500 lbs., the effect in all cases on the long duration objectives is to add a flight mission which suggests that APP-A be flown alone.

1021-PLH-bap

P. L. Havenstein

Attached:
Figure 1

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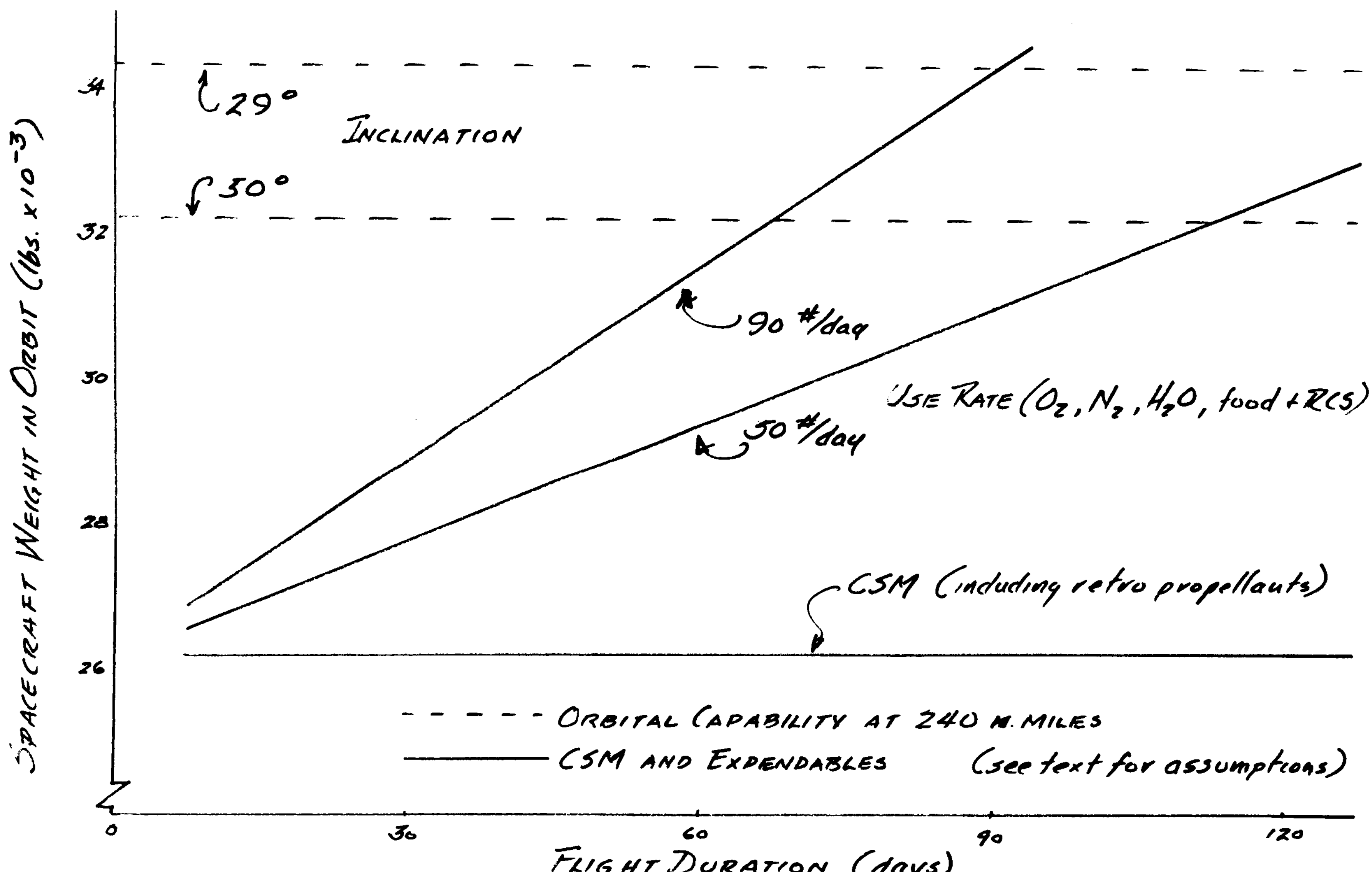

EXPERIMENT PAYLOAD CAPABILITIES
DURING 1969-70 RESUPPLY MISSIONS

Figure 1